The Great Singularity Circle Jerk

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Strip the empirical claim to what has actually been measured, and the inventory is short. Stars orbit something dark and very massive at the center of our galaxy; we have tracked S2's twenty-year ellipse around Sagittarius A* and can fit its motion to general relativity, within a few percentage points. X-ray binaries throughout the disk emit spectra consistent with accretion onto compact, gravitationally deep objects whose mass functions exceed any neutron-star upper limit. Gravitational-wave detectors record the chirps of two such compact objects spiraling together, and the resulting waveforms agree with numerical-relativity templates built from a vacuum solution of Einstein's equations called the Kerr metric. The Event Horizon Telescope, a planet-scale interferometer operating at 230 gigahertz, has imaged the immediate vicinity of M87* and Sagittarius A* and produced rings of emission whose diameters are consistent with what the Kerr exterior predicts.

That is the entire empirical content. Compact dark masses with near-Kerr exterior geometry, observed across four independent channels, in approximate agreement with the same family of solutions. Everything else, every claim about event horizons as one-way membranes you can cross but never return from, every assertion about singularities of infinite density at the center, every paragraph in every popular science book about Hawking radiation and the information paradox, every theoretical edifice of complementarity and firewalls and ER=EPR and replica wormholes and the Page curve, sits past the empirical anchor. None of it has astrophysical observational contact. None of it is implied by what we have measured. All of it depends on extrapolating the same vacuum solution into regimes where the equations themselves break down and then treating the breakdown as the content of the breakdown rather than as the signal of the model's reach being exceeded.

This is not a fringe claim. Vitor Cardoso and Paolo Pani, in their 2019 *Living Reviews in Relativity* synthesis of the field, write that "there is no direct observable associated to the horizon." Erik Curiel, in a Nature Astronomy paper the same year, observes that "there is no agreed upon definition" of a black hole, and that physicists in different subfields "conceive of and reason about them in radically different, and often conflicting, ways." Stephen Hawking, the architect of the entire post-1974 information-paradox edifice, published a paper in 2014 stating plainly that "the absence of event horizons mean that there are no black holes, in the sense of regimes from which light can't

escape to infinity." The 2025 Copenhagen Survey of 85 black-hole specialists found that only 29 percent endorsed the literal classical singularity at the center, while a larger combined fraction endorsed fuzzball, bounce, and quantum-gravity alternatives.

The field's own foundations literature has been quietly retreating from the orthodox picture for at least a decade. The lay infrastructure has not noticed. NASA's StarChild educator page still asserts that "a singularity resides in the center of all black holes." Encyclopedia entries describe the center as "a point with zero volume and infinite mass." Documentaries render the singularity in three-dimensional graphics. Christopher Nolan's *Interstellar*, with Kip Thorne consulting, showed audiences the inside of a tesseract inside a rotating black hole. The science-literate lay defender will tell you with religious confidence that beyond the event horizon, time and space swap roles, and that all matter is crushed to a dimensionless point at the center.

This is a textbook case of symbolic lock-in, the failure mode of a representational system that has lost contact with its referent while preserving, even amplifying, its internal coherence. A symbolic system enters lock-in when three conditions are met. First, its elements are self-consistent and mutually reinforcing. Second, its accuracy is no longer tested against the persistence-qualified structures it was built to map. Third, its continued existence depends more on its capacity to reproduce itself than on its capacity to track reality. The black-hole construct, meaning specifically the popularized, textbook-ontological, lay-defended construct, not the vacuum solution and its observed exterior consequences, meets all three conditions. The math is excellent within each layer. The empirical contact at every layer past the exterior geometry is either zero or formally degenerate with alternatives. The popularization apparatus, the funding apparatus, the prestige apparatus, and the pedagogical apparatus all reinforce the construct against revision.

What makes black holes such a clean case study is not that the physicists are wrong, in some simple sense, about the equations. They are not wrong about the equations. What they are wrong about, or, more precisely, what the popularization apparatus and the textbook ontology and the lay-defender are wrong about, is the ontological status of the symbolic objects the equations produce when pushed into regimes the equations themselves flag as broken. The singularity at r=0 in the Schwarzschild solution is what the equations “say” when their assumptions stop holding. We have reified that breakdown as the content of the breakdown. Then we built, on top of that reification, a sixty-year industry whose principal accomplishments are mathematical consistency proofs about an object whose existence we have no way to verify.

Symbolic lock-in played out as cleanly here as it has anywhere in modern intellectual history. A 1916 vacuum solution with a coordinate problem became a 1939 "frozen star" became a 1964 magazine word became a 1967 institutional brand became a 1974 radiation prediction became a 1993 paradox became a 2012 firewall became a 2019 island formula became, in the lay imagination, a fully-realized thing in our sky that we “know” facts about. Each transmission added confidence while subtracting empirical anchor. By the time the symbol reached the public, the contested mathematical region had become an object the public would defend against doubt, and the field, having built half a century of careers and prestige on the symbol, could not easily walk back the metaphysical commitments, even when its own foundations literature began to.

The Wheeler-coined-it story is one of those origin myths that physics tells itself, polished by repetition until the rough edges are gone. The polished version goes something like this; John Archibald Wheeler, the great Princeton theorist, in his 29 December 1967 lecture to the American Association for the Advancement of Science, coined the term "black hole" to replace the awkward "gravitationally completely collapsed object," and the term immediately took hold, and thus, our modern era of black hole physics began. The unpolished version is more interesting and more revealing.

The phrase "black hole," applied to gravitationally collapsed objects, appeared in print in Ann Ewing's article "'Black Holes' in Space," published in *Science News Letter* on 18 January 1964. Ewing was reporting on the December 1963 American Association for the Advancement of Science meeting in Cleveland, Ohio, at which Hong-Yee Chiu had organized a session on dense astrophysical objects. Her sentence, "such a star then forms a 'black hole' in the universe." This predates Wheeler's first published use by four years. Chiu, in later interviews with the science historian Marcia Bartusiak, recalled having heard the phrase years earlier still at a seminar in Princeton around 1960 or 1961, when Robert Dicke was discussing gravitationally collapsed objects and referred to them, somewhat morbidly, as being "like the Black Hole of Calcutta," a reference to the 1756 incident in which East India Company prisoners died of suffocation in a small dungeon. Chiu was not certain whether he himself had used the term at the 1963 meeting; he was certain it had not originated with him.

Wheeler's own account, in his autobiography *Geons, Black Holes, and Quantum Foam*, is self-deprecating on the point. He recalls that at a 1967 conference he had been searching for months for a better term than "gravitationally completely collapsed object," and that an unidentified audience member proposed "black hole." Wheeler liked it, used it in his AAAS lecture later that year, and published the 1968 version in *American Scientist*. Iliopoulos and Tomaras, in a 2018 historical

reconstruction, document the full sequence and the unease of conference organizer Vittorio Canuto when confronted decades later with Wheeler's account.

What is genuinely interesting about the moment is not the coinage but the institutional uplift. The phrase had been kicking around for at least seven years, in print for at least three. What Wheeler supplied was the senior-physicist legitimization. He had, as Bartusiak put it, "the authority to give the scientific community permission to use the term." Once Wheeler used it, the textbooks could use it. Once the textbooks used it, the popularization apparatus could use it. Once the popularization apparatus used it, the public could imagine it. The brand had a sponsor.

The Soviet/American split during exactly this period is a controlled experiment that the history of physics has not adequately appreciated. While Wheeler was preparing his institutional sponsorship of "black hole" in the American context, Soviet theorists led by Yakov Zeldovich and Igor Novikov were using a different term, "frozen star." The terminology mattered. A frozen star is something that an asymptotic observer watches collapse but never quite sees complete, a process suspended at the threshold of an event horizon that, in the observer's coordinates, takes infinite time to form. The phrase keeps the contested mathematical region in view as a process rather than closing it off as a thing. A black hole, by contrast, is grammatically a noun, an object, a *hole* in space, a *thing* with an inside, an entity with which the listener can have an imagined relationship.

The American name won. The Russians eventually adopted it. Decades later, in 2024, Ram Brustein and A.J.M. Medved would publish a paper, *Frozen stars: Black hole mimickers sourced by a string fluid*, explicitly reviving the Soviet terminology as the name for an alternative class of horizonless ultracompact objects that, "to an external observer, looks exactly like a Schwarzschild black hole, but with a different interior geometry and matter composition." The terminological revival is itself a tell; it acknowledges that the choice of name in 1967 was contingent, that the closing of the discussion was premature, and that the alternative framing has been waiting in the wings the whole time.

A name does not wait for a thing to unfold; it seizes on first contact and rushes ahead of becoming. This is what happened in 1967. The contested mathematical region was named before its ontological status was settled, and the name then disciplined all subsequent inquiry. After "black hole" entered the institutional vocabulary, the discussion of *whether* the object in question had a true horizon, a true interior, or a true singularity, became a discussion *of* the properties of the named object rather than of whether the object existed as named. The grammar shifted from "is there such

a thing" to "what is it like." The closure of the open question happened at the lexical level, before any of the relevant physics had been done.

Sixty years later, the lay defender of literal singularities is defending a symbol whose ontological commitments were never warranted by the math and have never been confirmed by observation. The defender did not, of course, make this commitment. Wheeler did, by giving the institutional sponsorship that hardened a contested phrase into a textbook ontology. The popularization apparatus did, by reproducing the textbook ontology in books and documentaries and educator pages. The public inherited the symbol with the ontology pre-installed and defends it now as if defending a fact rather than a 1967 naming decision.

To make this diagnosis precise, it helps to walk the layers of the black-hole construct, distinguishing what is empirically anchored from what is theoretically posited, and asking at each layer what the field's own foundations literature says about the warrant for the claim. It is an exercise is humility. The orthodox layers above the immediate exterior geometry are not held with the confidence the popularization apparatus suggests. The specialists know they are extrapolating. The textbooks and documentaries do not, on the whole, transmit this.

The bottom layer is the empirical inventory. Compact dark objects exist; we have multiple independent channels of observation that constrain their mass, their gravitational field at moderate distances, and the timing of stellar and gas-cloud interactions in their vicinity. The S-star cluster orbits Sagittarius A* on trajectories that fit a Keplerian-relativistic potential anchored to a central mass of about four million solar masses confined within a volume too small to be a star cluster. Cygnus X-1 and its successors emit thermal and non-thermal radiation consistent with accretion onto an object whose mass exceeds the Tolman-Oppenheimer-Volkoff limit for any plausible neutron-star equation of state. LIGO and Virgo have detected dozens of compact-binary inspirals whose component masses exceed the same limit. The EHT 2019 and 2022 images of M87* and Sagittarius A* show rings of emission at angular diameters consistent with the Kerr exterior prediction. None of this is in serious dispute. The construct of compact dark masses with near-Kerr exterior geometry is as empirically secure as anything in modern astrophysics.

The next layer, the exterior Kerr extrapolation, is also well-anchored. The Kerr metric is a vacuum solution of Einstein's equations characterized by two parameters, mass and angular momentum, and it makes specific predictions for the geodesic structure of the spacetime outside the central object. These predictions are testable through ringdown spectroscopy of merging black-hole candidates. Maximiliano Isi, Matthew Giesler, Will Farr, Mark Scheel, and Saul Teukolsky

reported in 2019 the detection of the fundamental quasinormal mode plus at least one overtone of the dominant ℓ=m=2 angular mode in the GW150914 ringdown, at 3.6σ confidence, "supporting the hypothesis that the GW150914 merger produced a Kerr black hole." Calderón Bustillo, Lasky, and Thrane reported a Bayesian odds ratio favoring the Kerr nature of the remnant. The exterior geometry is being probed; the no-hair theorem is being tested. The tests are not yet definitive at high precision, but they are not consistent with arbitrary alternatives either. This is real science with real referential anchoring.

The third layer is where the cliff is. A true event horizon, meaning the global one-way membrane defined by the asymptotic light-cone structure of the spacetime, the surface from which no future-directed timelike curve can reach future null infinity, is the defining feature of a black hole *as a black hole*, distinguishing it from any merely-very-compact-object, and it is observationally inaccessible.

The Cardoso-Pani Living Review states flatly "there is no direct observable associated to the horizon." The reason is straightforward. A true event horizon is a global construct; it depends on the entire future history of the spacetime. No local observation can confirm it. Every "evidence for the horizon" claim in the astrophysical literature is, at best, an absence-of-surface-emission argument. Ramesh Narayan and Jeffrey McClintock, in their advection-dominated accretion flow (ADAF) work since the late 1990s, have argued that quiescent X-ray binary systems with black-hole candidates are dimmer than those with neutron-star candidates by orders of magnitude, and have interpreted this as evidence that energy is disappearing through a horizon rather than being released at a surface. This is an inference, not a measurement. It is observationally degenerate with any object whose surface lies inside its photon sphere and which absorbs more than it reflects.

The list of such alternatives is by now extensive. Mazur and Mottola's gravastars are de Sitter interiors matched to Schwarzschild exteriors through a thin shell sitting a Planck length outside r=2M; from outside, they are indistinguishable from black holes. Mathur's fuzzballs, derived from string theory, are horizon-sized quantum microstates with no smooth horizon and no interior singularity. Boson stars composed of self-gravitating scalar fields can be configured to reproduce the EHT crescent images; Olivares et al. showed this explicitly. Brustein and Medved's frozen stars, Mottola's gravitational vacuum condensates, regular black holes, Planck stars, 2-2 holes, dark stars, Q-stars, the bestiary of horizonless alternatives is large, and Vagnozzi et al. conclude that "a number of well-motivated alternative scenarios, including BH mimickers, are far from being ruled out at present."

The EHT collaboration's own 2022 Sgr A* Paper VI is unusually candid about this. The paper considers the possibility that Sagittarius A* is a compact object with a surface that absorbs and thermally re-emits incident radiation. Under specific assumptions about energy balance, they argue that a thermal surface can be ruled out and a fully reflective surface is unlikely. Carballo-Rubio, Di Filippo, Liberati, Pacilio, and Visser, in a critical response, point out that the constraint relies on the extremely strong assumption of perfect balance in the energy exchange between the accretion disk and the central object, and that this assumption is violated whenever the surface has any non-zero absorption coefficient. The debate is technical, but the structural point survives. The EHT 2022 result is a constraint on a narrow class of alternative models, not a positive detection of an event horizon.

The fourth layer, the singularity at r=0, is where the foundations literature openly admits breakdown. The Penrose 1965 singularity theorem proves the existence of incomplete null geodesics in spacetimes satisfying certain global and energy conditions. It does not prove the formation of a black hole. It does not prove the existence of "infinite density" anywhere. It does not even prove the existence of a "point"; geodesic incompleteness is a property of geodesics, not of a missing region with definite coordinates. Klaas Landsman, in a careful 2021 analysis, writes that the theorem "fails to prove the existence or formation of black holes" and that "Penrose himself was well aware of this gap." Penrose's subsequent introduction of the weak cosmic censorship hypothesis in 1969, and the strong cosmic censorship hypothesis in 1979, were responses precisely *to* this gap. The conjecture, which remains unproven, asserts that physically reasonable initial data do not produce naked singularities. The conjecture is a placeholder for the work the theorem cannot do.

Worse, the energy conditions assumed in the Penrose-Hawking theorems are known to be violated by quantum fields. The null energy condition fails pointwise for the Casimir effect; semiclassical configurations violate it generically; quantum inequalities relax it but do not restore it. The antecedent of the singularity theorem is not cleanly satisfied in nature. The theorem proves geodesic incompleteness in classical general relativity under conditions that quantum field theory contradicts. Whatever we are inferring from the theorem about the actual physics of gravitational collapse, we are inferring it from a setup whose assumptions we know to be too strong.

The Copenhagen Survey provides direct sociological evidence of where the field actually stands on the question. Chen, Halper, and Afshordi surveyed 85 specialists at the "Black Holes Inside and Out" conference in August 2024. Of 75 respondents to the relevant question about what happens to matter at the center of a black hole, only 22 physicists, or 29 percent, endorsed "It is crushed into a singularity." Twelve endorsed the fuzzball picture, nine endorsed a bounce into our universe, eight

endorsed a bounce into another universe, and various other non-classical options received non-trivial support. The combined non-singularity vote was a larger plurality than the singularity vote. Whatever the textbooks say, the field's own working specialists are 71 percent unconvinced of the literal classical singularity that NASA's StarChild page asserts as fact.

The fifth layer is where the structural absurdity becomes hard to ignore. Hawking radiation has never been observed for any astrophysical black hole. The Hawking temperature of a black hole of mass M is given by $T_H = \hbar c^3/(8\pi G M k_B)$, which for a solar-mass black hole works out to about 6.2 × 10^{-8} kelvin; that is more than seven orders of magnitude below the cosmic microwave background temperature of about 2.7 kelvin. The smallest astrophysical black hole, at roughly three solar masses, has a Hawking temperature still buried far beneath the CMB. An evaporating black hole only becomes hotter than its background after the universe has cooled below its temperature, which for any astrophysical black hole occurs on timescales of order 10^{67} years or longer. Hawking radiation, in the astrophysical sense, is unobservable in principle on any timescale relevant to human or cosmological epochs.

The black hole information paradox, the apparent contradiction between the unitarity of quantum mechanics and the thermal character of Hawking radiation, is a paradox between two unobserved phenomena. Hawking radiation has never been measured. The Page curve, derived by Don Page in 1993 as the entanglement-entropy trajectory required if unitarity is to be preserved, is a *requirement* of unitarity, not a *measurement* of anything. The AMPS firewall paradox of 2012, sharpened by Almheiri, Marolf, Polchinski, and Sully, identifies an inconsistency among four theoretical principles, unitarity, no-drama-at-the-horizon, low-energy effective field theory, and the equivalence principle, when applied to evaporating black holes past the Page time. The inconsistency is real *given the assumptions*. The assumptions cannot be checked. Maldacena and Susskind's ER=EPR proposal of 2013 identifies maximally-entangled quantum systems with non-traversable Einstein-Rosen bridges; the proposal has no operational test for astrophysical black holes. Penington, Almheiri-Engelhardt-Marolf-Maxfield, and the island-formula community derived the Page curve from quantum extremal surfaces in 2019; Almheiri-Hartman-Maldacena-Shaghoulian-Tajdini extended this through replica wormholes in 2020. The derivations are deep mathematics. They are performed in JT 2D dilaton gravity or in pure AdS/CFT. Neither of these is the spacetime we live in. The results are not falsifiable by any astrophysical observation that has been, or that anyone has proposed could be, performed.

Erik Curiel's 2019 *Nature Astronomy* summary is unflinching; "we have absolutely no experimental or observational evidence for any of it, nor hope of gaining empirical access any time soon to the regimes where such effects may appreciably manifest themselves." This is a peer-reviewed assessment, in a *Nature* journal, by a philosopher of physics writing from inside the foundations community of the field he is describing. The field, when speaking carefully to itself, knows where the empirical anchor is and where it isn't. The popularization apparatus does not transmit this.

The sixth layer is folk metaphysics; the lay-defender's confident assertion that singularities are real, that event horizons are physical surfaces, that Hawking radiation is happening in the sky right now, that the information paradox is a real puzzle about real objects, and that ER=EPR is a deep insight into the fabric of reality. NASA StarChild states "a singularity resides in the center of all black holes." EBSCO Research Starters says "the heart of a black hole is a singularity, a point with zero volume and infinite mass." OpenStax Astronomy 2e is more careful, hedging with "is thought to have" and acknowledging that "we do not yet have the physical understanding or the mathematical tools to describe the singularity itself, or even if singularities actually occur." The careful hedge is rare; the flat assertion is common. The gap between the 29 percent of specialists who endorse the literal singularity and the lay-source consensus that asserts it as fact is, itself, the symbol's signature.

The most damning single document in the case for symbolic lock-in is Stephen Hawking's January 2014 manuscript *Information Preservation and Weather Forecasting for Black Holes*. It is two pages. It abstracts a presentation Hawking gave at the Kavli Institute for Theoretical Physics in August 2013. It is brief, it is informal, and it is one of the most consequential retractions in the history of theoretical physics. The relevant sentence is short enough to quote in full: "The absence of event horizons means that there are no black holes, in the sense of regimes from which light can't escape to infinity. There are, however, apparent horizons which persist for a period of time."

This is the man who wrote *A Brief History of Time*. This is the architect of the post-1974 information-paradox edifice. This is the physicist whose name is, in the public imagination, more closely associated with black holes than any other scientist. And he is conceding, in plain language, that the Layer-2 entity, the global one-way membrane he assumed for forty years, on which the entire information paradox was constructed, does not exist. What exists, he suggests, is an apparent horizon, a local marginally-trapped surface that persists for a finite period of time. The global construct, the thing that defines a black hole *as* a black hole, may have been a fifty-year theoretical fiction.

The popular-science response was muted. NBC News ran a brief item titled "Stephen Hawking shakes up theory (again): Black holes are actually gray." Other outlets noted the paper and moved on. *A Brief History of Time* remained in print, and remains in print today, with its description of event horizons as physical surfaces intact. The textbooks did not update. The educator pages did not update. The documentaries did not update. The lay defender of the literal singularity heard nothing.

This is the lock-in mechanism in its purest form. The apex authority of the popular construct revises the construct in a peer-archived, plain-language document, and the institutional infrastructure absorbs the revision without disturbing the symbol. "Hawking changed his mind again" enters the discourse as a quirk of the man rather than as a revision of the field's central claim. The symbol persists because the symbol's persistence is what the institution rewards, not its alignment with reality.

The most powerful symbolic lock-in attractors are characterized by terminality, eternity, compression, and warrant, and one of their structural properties is the capacity to absorb contradiction without revision. Apparent anomalies are reframed as tests of faith. Replace "faith" with "interpretation" and you have the mechanism by which Hawking 2014 was metabolized by the popular black-hole construct. The construct did not break. The construct absorbed its founder's retraction and continues to be defended by people who had never heard of it. This is what apex symbols do.

I want to be careful here. Hawking is not the final word, and his technical content is contested. Some specialists argue that the distinction between event horizons and apparent horizons is a red herring in this context, that what Hawking meant was modest, that the popular framing of "no event horizons, therefore no black holes" overstates the technical claim. These specialists may be right; I am not in a position to adjudicate the question. The lock-in claim does not depend on Hawking being technically definitive. It depends on the *response* to Hawking and on the field's, and the public's, capacity to register a retraction by the apex authority while continuing to describe the world as if the retraction had not occurred. That capacity is the diagnostic.

If one wants to see the symbolic-lock-in mechanism in real time, with the lock-in still operating, the black hole information paradox literature is the exhibit. The literature is large, technically deep, prestigious, and consists, very nearly in its entirety, of symbolic manipulations between unobserved phenomena in spacetimes we do not inhabit.

Begin with what the paradox is. In 1974, Hawking derived, using quantum field theory in the fixed background of a Schwarzschild spacetime, that a black hole should emit thermal radiation at a temperature inversely proportional to its mass. The derivation assumes the existence of the black hole exterior, a globally well-defined event horizon, free quantum fields, and no backreaction of the radiation on the geometry. In 1975 he amplified the implications; as the black hole radiates, it should lose mass, eventually evaporating entirely. If the radiation is genuinely thermal, that is, if it carries no information about the initial state of whatever fell in, then the final state of the universe is pure thermal radiation, and the information about the initial state has been lost. This contradicts the unitarity of quantum mechanics, which requires that the wavefunction at later times be unitarily related to the wavefunction at earlier times, with no loss of information.

This is the paradox. The paradox is real *given the assumptions*. The question is what to do about it. The answer, in 1975, might reasonably have been, "this is a fascinating tension between two of our best theories, and it suggests that one or both of them must be modified in the strong-gravity regime; until we have either observed Hawking radiation or developed a workable theory of quantum gravity, we should treat this as a conceptual puzzle to be revisited when more is known." That was not the answer the field chose. The answer the field chose was to take the paradox as primary data, to treat the existence of Hawking radiation and the validity of unitarity as established, and to embark on a fifty-year quest to resolve the paradox using theoretical techniques alone.

The quest has produced extraordinary mathematics. Susskind, Thorlacius, and Uglum's 1993 black hole complementarity proposal argued that the apparent contradiction between the infalling observer and the asymptotic observer was no contradiction because no single observer could verify both perspectives simultaneously. AMPS in 2012 sharpened complementarity into a firewall; if unitarity holds and the equivalence principle holds and effective field theory holds outside the horizon, then the equivalence principle must fail at the horizon, and an infalling observer must encounter a wall of high-energy radiation. Mathur showed in 2009 that small corrections to the semiclassical analysis cannot rescue unitarity. Maldacena and Susskind in 2013 proposed ER=EPR: that two maximally entangled quantum systems are connected by a non-traversable Einstein-Rosen bridge, that entanglement and geometry are dual aspects of the same underlying structure. Penington in 2019, and Almheiri-Engelhardt-Marolf-Maxfield independently the same year, derived the Page curve from quantum extremal surfaces. Almheiri-Hartman-Maldacena-Shaghoulian-Tajdini in 2020 extended the result through replica wormholes, gravitational saddle points in which the spacetime topology fluctuates to produce the entanglement-entropy curve required by unitarity. The

2021 *Reviews of Modern Physics* article by Almheiri, Hartman, Maldacena, Shaghoulian, and Tajdini is the canonical synthesis of the island-formula approach.

All of this is real and deep mathematics. Some of it is, within its assumed frameworks, theorem-like; that is, derivable from premises with the precision and rigor we expect from a mathematical proof. It would be philistine to dismiss the work as mere symbolic manipulation in a derogatory sense. The work is hard, the practitioners are brilliant, and the techniques have applications beyond gravity in condensed matter, in quantum information, and in pure mathematics.

My diagnostic claim is narrower and more specific. The claim is that *this work is not what the popularization apparatus says it is*. It is not the resolution of a paradox about real objects in our sky. It is the resolution of a paradox between two theoretical claims, the existence of Hawking radiation and the validity of unitarity, in spacetimes that are not the spacetime we live in. The Page curve has been derived in JT 2D dilaton gravity coupled to a non-gravitating bath, and in pure anti-de Sitter spacetime via AdS/CFT. JT 2D gravity is one-dimensional gravity plus time; our universe is three-dimensional gravity plus time. AdS/CFT works in negatively-curved spacetimes; our universe is positively-curved at the largest scales. The replica-wormhole computations work in 2D dilaton gravity with very specific matter content. None of these results has been derived in any setting that approximates our universe at the level of detail required to say that the analogous statement holds for an astrophysical black hole. The work is real mathematics, but mathematics is not the physics of objects in our sky.

This is symbolic-lock-in in flagrante. A community of brilliant theorists, well-funded, publishing in the highest-prestige journals, producing technical work of genuine depth, and not noticing, or noticing but not registering, that the work has no astrophysical referent and no operational test. The work is internally coherent. The work is self-reinforcing, each result motivates the next, each technique generates new questions. The work is institutionally rewarded. The work is, by every available measure, succeeding *as a body of mathematical research*. What it is not is the resolution of a problem about real things.

Sabine Hossenfelder, writing on her Backreaction blog in 2015, said "it is hard, sometimes, to understand why anyone would waste time on a problem as academic as black hole information loss. Many physicists today work on topics that, like black hole information loss, seem entirely detached from reality." This is a working theoretical physicist saying out loud what the lock-in diagnostic predicts. In *Lost in Math*, Hossenfelder generalized the diagnosis to large parts of contemporary fundamental theory; "these 'too good to not be true' theories are actually untestable

and they have left the field in a cul-de-sac." Carlo Rovelli, on Sean Carroll's *Mindscape* podcast in 2018, drew the historical analogy explicitly to phlogiston; "in the history of science there have been huge debates, huge disagreements... phlogiston... and usually one of the two sides turned out to be right, and the other turned out to be wrong."

The lock-in is not invisible to the participants. Some of them name it. The naming is contained, professionally costly, and does not disturb the body of work that continues to be produced. This is also what apex symbols do; they tolerate criticism while continuing to reproduce themselves through the institutional channels that the criticism does not control.

Horizonless alternatives, the bestiary of objects that reproduce Kerr-exterior observations to current precision while doing without an event horizon, a singularity, or any of the post-1974 paradox furniture, are an under-publicized empirical fact about the field. The lay reader, fed standard textbook ontology, would not know that there is substantial peer-reviewed literature proposing that the central objects of M87 and the Milky Way may not be black holes in the technical sense at all.

Pawel Mazur and Emil Mottola proposed gravastars, gravitational vacuum condensate stars, in 2001, with a more detailed exposition in *Proceedings of the National Academy of Sciences* in 2004. A gravastar has a de Sitter interior, a thin shell at approximately r=2M, and a Schwarzschild exterior. The abstract is explicit; "the new solution has no singularities, no event horizons, and a global time... Hence, unlike black holes, the new solution is thermodynamically stable and has no information paradox." The thin shell sits just outside the would-be event horizon; from outside, the gravastar is indistinguishable from a black hole to current observational precision. Mottola's 2022 *Snowmass* white paper develops the effective-field-theory underpinnings; the gravastar yields "a non-singular 'BH' interior and physical surface replacing the classical event horizon, which is a gravitational condensate star free of any information paradox."

Samir Mathur proposed fuzzballs in the mid-2000s, with a key exposition in *Fortschritte der Physik*. Fuzzballs arise from the string-theoretic counting of black-hole microstates; rather than a single classical geometry with a horizon and a singularity, a fuzzball is a horizon-sized superposition of microstate geometries, each of which terminates smoothly before the would-be horizon. There is no global event horizon. There is no interior singularity. The information of the microstate is carried by the fields near the would-be horizon, and the information paradox dissolves because there is no longer a region behind a horizon from which information needs to escape.

Boson stars, self-gravitating configurations of complex scalar fields, can be tuned to be ultracompact, with shadow images closely resembling Kerr black holes. Vincent et al. showed that

EHT-like images of accreting boson stars are "extremely similar" to Kerr images for appropriate parameter choices. Olivares et al. demonstrated that the imaging-based criterion for distinguishing boson stars from black holes is "general enough to apply to other horizonless and surfaceless black hole mimickers."

Other candidates populate the bestiary. Regular black holes with curvature regularization at the would-be singularity; Planck stars in loop quantum gravity, in which collapse halts at Planck density and rebounds; 2-2 holes in quadratic gravity; dark stars in Bose-Einstein condensate models; Q-stars composed of non-topological soliton configurations; Brustein-Medved frozen stars sourced by anisotropic string fluid; ultracompact objects in scalar-tensor and Horndeski-class modified-gravity theories. Each has its own technical literature. None is currently distinguishable from a Kerr black hole by available astrophysical observations.

The 2023 review by Sunny Vagnozzi and collaborators in *Classical and Quantum Gravity* summarizes the situation with appropriate hedging; "a number of well-motivated alternative scenarios, including BH mimickers, are far from being ruled out at present." The 2022 *EHT Paper VI* on Sgr A* constrains specific classes of alternatives, those with thermal hard surfaces under particular energy-balance assumptions, but acknowledges that broader classes of alternatives remain viable.

The structural significance of the bestiary is twofold. First, it shows that the orthodox picture is *not selected for* by current observations; it is one possibility among many that the data are consistent with. The standard claim that we have "observed black holes" should be parsed as "we have observed objects whose exterior gravitational and electromagnetic phenomena are consistent with the Kerr metric to current precision." That is a real result. It is not equivalent to "we have observed event horizons" or "we have observed singularities." Second, it shows that the field at the technical frontier is *much more pluralistic* than the popularization apparatus suggests. The textbooks and documentaries describe the standard picture. The technical literature explores the bestiary. The gap between technical pluralism and popular monoculture is, again, the symbol's signature.

The plurality of symbolic systems, while making coordination more complex, serves as a protection against totalizing lock-in. The horizonless-alternatives literature is exactly this kind of plurality, operating at the technical level. It provides alternative mappings to reality that the standard picture lacks. What it does not provide is the popular legibility that would translate technical pluralism into public skepticism of the singular orthodox picture. The technical literature is healthy, and the popular monoculture remains intact.

The history of physics provides a small number of well-developed examples of symbolic lock-in eventually dissolving, theoretical edifices that grew internally coherent and prestigious while remaining empirically anchored to limited data, and that were dissolved not by counter-evidence but by reformulation, often abruptly. The luminiferous ether is the canonical case, dissolved by Einstein's 1905 special relativity not because new evidence against it had emerged, Michelson-Morley was eighteen years old, but because reformulation made the ether unnecessary. Phlogiston, the eighteenth-century principle of combustion, was dissolved by Lavoisier's oxygen reformulation, which absorbed all the empirical successes of phlogiston theory while abandoning its symbolic furniture. Caloric, the imagined fluid of heat, was dissolved by the kinetic theory's reframing of heat as molecular motion.

The most precise analogue, however, is Vulcan, the hypothesized intra-Mercurial planet whose existence was inferred by Urbain Le Verrier in 1859 to explain the anomalous precession of Mercury's perihelion. Le Verrier was the man who had predicted Neptune from perturbations of Uranus, the most spectacular predictive success of Newtonian celestial mechanics. When Mercury's orbit failed to match Newtonian predictions, Le Verrier applied the same technique and inferred another planet, closer to the sun, perturbing Mercury. Vulcan was duly "observed" by reputable astronomers; Edmond Lescarbault in 1859 most prominently, but others followed. The observations were widely accepted; Le Verrier was elected to the Légion d'honneur in part for the discovery. Astronomers searched for Vulcan during solar eclipses for the next half-century. Some reported seeing it. The planet was, in the institutional and popular sense, real.

What dissolved Vulcan was not a counter-observation. No eclipse expedition produced unambiguous evidence that Vulcan did not exist; the failure to find it was always susceptible to explanations involving small size, unfavorable orbital geometry, or instrumental limitations. What dissolved Vulcan was Einstein's calculation in November 1915, showing that the Mercury anomaly was predicted by general relativity without any additional planet. The theoretical reformulation removed the need for the symbol, and the symbol, which had been observed by reputable people, defended by senior astronomers, and integrated into the official astronomical canon for half a century, simply ceased to exist as a serious scientific proposition. The "observations" of Vulcan were, retrospectively, classified as instrumental artifacts, faint stars misidentified, or wishful seeing.

The structural parallel to the singularity, and to the broader Layer-3-through-Layer-5 black-hole edifice, is exact. A theoretical entity is inferred from a successful theory applied beyond its tested domain. The entity is supported by the prestige of the theory and the absence of a superior

alternative. The entity is "observed" or "confirmed" by reputable specialists in ways that, on close examination, depend on the antecedent assumptions of the theory. The entity becomes integrated into the popular and pedagogical canon. The entity survives because no reformulation has yet emerged that makes it unnecessary. When and if such a reformulation does emerge, Einstein-on-Vulcan, oxygen-on-phlogiston, relativity-on-ether, the entity will dissolve quickly, and the cultural memory will reconfigure to treat the previous belief as an embarrassing reminder of the limits of theory-driven inference.

The historical parallel is structural, not prophetic. Vulcan dissolved when general relativity emerged; I am not in a position to know whether a corresponding reformulation will emerge for quantum gravity, or whether it will dissolve the singularity, the horizon-as-one-way-membrane, or the information-paradox edifice. What I am confident of is the structural claim; theoretical edifices that grow intricate to preserve internal coherence while their empirical anchor remains static have a documented history of *dissolution by reformulation*. The black-hole edifice exhibits this structural signature. Whether it will dissolve, and on what timescale, is open. That it could dissolve, that the public defense of singularities and event horizons and Hawking radiation as fact is the structural twin of the Vulcan defense, is not.

Why do ordinary people argue for the literal existence of singularities they cannot in principle ever observe? Why does the lay defender, confronted with the gap between specialist hedging and textbook assertion, side with the textbook? Why is "black hole" a noun in the public imagination, and why does that noun come pre-installed with an interior, a center, a singularity, and the unambiguous ontology of a thing?

The answer is partly the naming mechanism I described earlier; a 1967 institutional decision, made by a senior physicist, transmitted through textbooks and popularizations, never seriously revisited at the lexical level. The answer is partly the popularization apparatus, which has incentives to render the construct concrete and visualizable rather than to transmit the uncertainty in which the specialists actually operate. The answer is partly the structure of education, which presents settled-seeming facts in introductory courses and reserves the foundations debates for graduate-level seminars that most physically-literate adults will never attend. The answer is partly the asymmetry between the cost of saying "we don't know what's inside a black hole" (loses the reader, sells fewer books, gets fewer documentary commissions) and the cost of saying "there's a singularity at the center" (loses nothing, sells well, looks good in computer-generated graphics).

Beneath all of this, I think, is the structure I identified. The black-hole construct has, by accident and by design, accreted the features of an apex symbolic lock-in attractor. It is *terminal*; the question "what is at the center of a black hole?" is answered by the singularity, and the singularity is by construction a point at which further inquiry is impossible. It is *eternal*; the symbol does not specify a date at which the singularity will dissolve or be revised. It is *compressed*; vast ranges of phenomena, the destination of all infalling matter, the resolution of the unitarity puzzle, the eventual fate of all stars heavy enough to collapse, are subsumed into the single referent. It is *self-warranting*; to invoke the construct is to render the inquiry settled, with the symbol functioning as the warrant for the closure.

These are the same structural properties that make the God-symbol the most durable lock-in attractor in human culture. The singularity is, structurally, a small God-symbol; a terminal compression that closes the chain of justification by being beyond appeal. Once you have the singularity, you do not need to ask further. The construct does for cosmology what God does for theology; it ends the regress.

The lay defender of literal singularities is, in this structural sense, doing exactly what the religious literalist does. Both have inherited a symbol whose ontological commitments were not warranted by the underlying inquiry. Both defend the symbol as if defending a fact. Both are unaware that the field's own foundations community, the theologians in one case, the foundations physicists in the other, has been hedging the relevant claims for decades. Both find the hedging, when they encounter it, harder to accept than the original assertion. The structural mechanism is identical. The decorations differ.

The lay defender is, by and large, not foolish or credulous. They are doing what reasonable people do with symbols; they are trusting the institutional infrastructure that transmitted the symbol to them. The NASA educator page is, on its face, a trustworthy source. The OpenStax textbook is, on its face, a trustworthy source. The documentary featuring credentialed physicists is, on its face, a trustworthy source. The lay defender's mistake, if it is a mistake, is not failure of reasoning. It is the absence of access to the foundations literature where the same physicists hedge the relevant claims. The lock-in is not in the lay defender's head. The lock-in is in the institutional gradient between the foundations literature and the popularization apparatus.

Symbolic systems enter lock-in when three conditions are met: high internal coherence, loss of referential feedback, and self-reinforcing reproduction. To these I would add a fourth, derived from

the God-symbol analysis, *terminal compression*, or the absorption of multiple distinct inquiries into a single referent that closes further investigation.

Apply the diagnostic to the black-hole construct, specifically meaning Layers 2 through 5 as I have defined them. *High internal coherence*, the mathematics is excellent within each layer. The exterior Kerr geometry, the global event horizon construct, the Penrose-Hawking singularity theorems, the Hawking radiation derivation, the AMPS firewall, ER=EPR, the island formula, each step is internally rigorous. The construct is not held together by sloppy reasoning. It is held together by tight reasoning operating on premises that are not themselves checkable.

Loss of referential feedback, at the empirical level, the construct is anchored only at Layers 0 and 1, the exterior phenomenology of compact dark masses. Cardoso and Pani state "there is no direct observable associated to the horizon." Curiel states "we have absolutely no experimental or observational evidence for any of it." The construct above Layer 1 has, by the field's own foundations literature's own admission, no operational test.

Self-reinforcing reproduction, the construct is institutionally reproduced through textbooks, popularizations, documentaries, educator pages, undergraduate curricula, graduate-level coursework, conference invitations, journal submissions, and tenure decisions. The reproduction is not a conspiracy; it is the ordinary functioning of an institutional infrastructure that has, over fifty years, organized itself around the construct. Disturbing the construct disturbs the infrastructure.

Terminal compression, the singularity ends the chain of inquiry about the interior. The event horizon ends the chain of inquiry about retrieval. The information paradox, the firewall, ER=EPR, and the island formula are *internal* moves within the construct that preserve its self-consistency; they do not generate external tests. The construct is, by design, sealed against external check.

All four conditions are met. The diagnostic is satisfied. The black-hole construct, as transmitted through the popularization apparatus and as defended in folk metaphysics, is the cleanest case of symbolic lock-in in contemporary physics.

I want to be careful, again, about what this claim does and does not assert. It does not assert that black-hole physicists are wrong about the mathematics. They are not wrong about the mathematics; the mathematics is, by and large, excellent. It does not assert that there is nothing at the centers of galaxies; there clearly are very massive, very compact, very dark objects, and we have measured many of their exterior properties to good precision. It does not assert that the construct will dissolve next year, or in fifty years, or ever; the historical examples of lock-in dissolution are encouraging but not predictive.

What the diagnostic asserts is narrower and more precise. It asserts that *the warrant for the popular-level, textbook-level, folk-metaphysics-level statements about event horizons, singularities, Hawking radiation, and the information paradox is much weaker than the popular transmission suggests*. The specialists know this; the foundations literature documents it; the popularization apparatus does not transmit it. The gap between specialist hedging and popular assertion is symbolic lock-in's signature. The construct persists because the institutional gradient between the foundations community and the lay public preserves it, not because the empirical evidence has compelled it.

This diagnostic is not nihilism. It is not the claim that we know nothing, or that the physics is bad, or that we should abandon the study of compact dark masses. The empirical anchor at Layers 0 and 1 is real and survives the diagnostic intact. We do know things about the exterior phenomenology of these objects. We know they exist. We know approximately how massive they are. We know that their exterior gravitational fields are well-approximated by Kerr to current precision. We can test the no-hair theorem in gravitational-wave ringdown. We can image their immediate vicinities with the EHT. None of this requires retreat.

What the diagnostic asks for is restraint above the empirical anchor. The singularity is what the equations say when their assumptions stop holding; treating it as a thing that exists is the categorial error this whole essay has diagnosed. The event horizon as a one-way membrane is observationally degenerate with horizonless ultracompact alternatives; treating it as a confirmed feature is unwarranted. The information paradox is a puzzle between two unobserved phenomena in spacetimes we do not inhabit; treating it as a real puzzle about real objects is overstatement. The solutions to the paradox, complementarity, firewalls, ER=EPR, islands, and replica wormholes, are deep mathematics in toy models; treating them as descriptions of features of objects in our sky is the same overstatement, layered.

In my essay on the Big Bang, I argued for treating apparent origin-events as *coherence horizons*, or boundaries of reconstructability beyond which the descriptive regime that successfully accounts for present observables cannot be extended without contradiction. That reframe is exportable. The singularity is not an entity; it is a coherence horizon. The event horizon, treated as a global one-way membrane defined by the asymptotic light-cone structure of the spacetime, is not a confirmed feature; it is a theoretical idealization whose observational signature is degenerate with multiple horizonless alternatives. The information paradox, treated as a puzzle to be resolved by

theoretical work alone, is not a fact about reality; it is a tension between two of our best theories whose resolution must await empirical contact in a regime we cannot currently reach.

This is not a retreat from science. It is a return to it. The science is the exterior phenomenology, the gravitational-wave templates, the EHT shadow measurements, the orbital fits. The science is also the foundations literature that has been hedging the relevant claims for a decade. What is not science is the institutional infrastructure that transmits Layer 3 and above as fact while the specialists below treat them as conjecture. The diagnostic asks us to align the transmission with the specialists.

There is one more thing the diagnostic asks. Apex symbolic lock-in attractors are characterized by being beyond appeal and sealing themselves against feedback that would otherwise force revision. The black-hole construct, in its popularized form, has the same structure for the same reason; nothing in its definition exposes it to the relevant observation. The singularity is, by construction, behind a horizon that, by construction, prevents the relevant test. The information paradox is, by construction, about a process, Hawking radiation, that, by construction, takes longer than the age of the universe to occur for any astrophysical black hole. The ER=EPR proposal is, by construction, untestable for the spacetimes we live in. The construct's resistance to revision is built into the construct.

This is the same structural property of the God-symbol. It is no accident that the two structures are similar. They are the same structural mechanism, the apex symbolic lock-in attractor, implemented in different cultural domains with different decorations. The religious literalist defends a symbol whose definition prevents the relevant test. The lay defender of literal singularities defends a symbol whose definition prevents the relevant test. The mechanism is identical. The decorations differ. In both cases, the institutional infrastructure that transmits the symbol has not, on the whole, transmitted the foundations literature that hedges the claim.

The Singularity has never been observed. It cannot be. The model says so. We built a folk metaphysics on top of what the model said when it broke.

The Tower of Babel is an archetype of what happens when a symbolic system becomes too unified to maintain referential feedback. The myth ends in catastrophic correction, divine scattering of the tongues, and forced plurality at the cost of social cohesion. The black-hole construct is not yet at the catastrophic-correction stage. It is, perhaps, at the stage where the masons have begun to hedge their bets at the upper levels while the lower courses still insist the Tower will reach the heavens. The technical pluralism in the bestiary of horizonless alternatives is the masons' hedge. The

popular monoculture, transmitted through educator pages and documentaries and textbooks, is the lower courses' insistence.

What the diagnostic recommends is the same thing it has always recommended; keep symbols open. Hold them lightly. Notice when they have begun to do work that the underlying inquiry does not warrant. Track the gradient between specialist hedging and popular assertion. When the gradient grows large, symbolic lock-in is operating, and the costs of correction are accumulating. The longer the lock-in persists, the more catastrophic the eventual correction.

I do not know what will dissolve the black-hole construct. I do not know whether anything will. I do know that the structure is present, that the diagnostic is satisfied, that the foundations literature has been telling us the relevant story for a decade, and that the institutional infrastructure has not, on the whole, transmitted the story. The Singularity has never been observed. The Event Horizon as a global one-way membrane has not been distinguished from horizonless alternatives. Hawking radiation has never been measured. The Information Paradox is a puzzle between two unobserved phenomena. The resolutions to the paradox are deep mathematics in spacetimes that are not the spacetime we live in.

These are facts the specialists know. They are facts textbooks, documentaries, and educator pages mostly do not transmit. The gap between the two is the lock-in, and the lock-in is the diagnostic, and the diagnostic, for any symbolic system in any domain, is the same. Hold the symbols lightly. Track the empirical anchor. Notice when the construct has detached. Name the detachment. And, when the structure permits, build the reformulation that will eventually dissolve the symbol back into what the inquiry actually warrants.

In 1915, on a question that had stood for half a century, Einstein dissolved Vulcan in an afternoon. The reformulation existed; the symbol ceased to be defensible. The reformulation for the singularity, the global event horizon, and the post-1974 paradox edifice has not yet been written. It may take longer than an afternoon. But the structural signature of a symbol awaiting dissolution is exactly what we see when we examine the black-hole construct with the foundations literature in hand. The specialists are hedging. The bestiary is growing. The founder retracted in 2014. The Copenhagen Survey shows 29 percent endorsement of what the textbooks state as fact. The gap is widening. The Tower is built high, and the masons have begun to look uneasy.

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